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/Nekotorye Rezultaty Meteorologicheskikh i Aerologicheskikh Issledovaniy v Antarktide za Period 1956-1966/

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SOME RESULTS OF METEOROLOGICAL AND AEROLOGICAL INVESTIGATIONS IN ANTARCTICA DURING THE PERIOD 1956-1966

The history of exploration of polar regions tells us that these areas have attracted the attention of meteorologists of many countries since ancient times, since these areas are permanently functioning refrigerators, playing an exceptionally important part in the general circulation of the atmosphere of the earth. This interest was confirmed by the measures adopted during the preparation and implementation of the program of the First International Polar Year. Great efforts were made to organize the exploration of the hardly-accessable Antarctic Continent, as the exploration of this region lagged far behind that of the Arctic.

The first systematic meteorological observations of the air temperature, atmospheric pressure, velocity and direction of winds over the antarctic waters were made in the summer of 1820 by their discoverers, F.F.Bellingshausen and M.P. Lazarev, during their boat cruise along the coast of Antarctica. The results of their observations represent the first climatic characteristic of this region.

Up to the present, as is well known, great progress has been made in the exploration of Antarctica. All of this has been achieved under the Soviet regime. Great advances in exploration were made particularly during 1932-1933, from the

beginning of the Second International Polar Year, and reached their maximum levels during the International Geophysical Year (IGY) and the International Year of the Calm Sun (IYCS). Among the most important problems of the IGY was the exploration of Antarctica, as noted by the 1954 Special Committee of the IGY, the most important part of the globe for the conduct of intensive investigations. Due to the efforts of the Soviet Antarctic Expedition the work got under way in 1956: regular observations were started in the interior of the continent. As early as 1957 the number of meteorological and aerological stations increased to the extent that it became possible to compile not only surficial synoptic charts, but also some pressure field topographic charts.

Aerometeorological observations in Antarctica are performed not only at the permanent meteorological stations, but also by mobile detachments aboard tractor-sleigh trains, on board flying aircraft and on ships, in the course of antarctic cruises. The early Antarctic expeditions were staffed by specialists who had a great deal of experience through working in the Arctic.

The full complex of meteorological observations was, in a number of cases, augmented by gradient observations and by measurements of the total ozone content, which during recent years have been performed regularly. Automatic registration of certain elements is now provided at a number of stations.

In spite of the unusual difficulties associated with antarctic radio sounding, resulting from high wind velocities and extremely low temperatures, the number of days when these observations were omitted during the last decade (1956 - 1966) was insignificant. By the first of January 1966 the number of radio soundings published by the Soviet specialists totaled more than 15,000. Most of them reached into the lower stratosphere. These soundings, together with those of the foreign antarctic stations, already provide an adequate basis for the development of a reliable climatic characteristic of the free atmosphere of Antarctica.

The results of observations are plotted daily on synoptic charts at Mirnyy. These charts are used first by the expedition's synopticians for weather predictions, frequently essential for scheduling of expeditionary operations as well as for those of the antarctic whaling fleet. Recently the analysis of synoptic charts has been improved through the employment of reproduction equipment which permits reception of surficial and altitudinal synoptic charts from a number of synoptic centers. Reproductions of these charts, drawn up at Mirnyy, are transmitted to the Soviet whaling fleet, as needed. This represents one important practical utilization of aerometeorological observations.

Interest in antarctic investigations is so great that scientists analyze the data obtained as soon as they receive

it, without waiting for it to accumulate over an extended period. Because of this fact we already have a number of important conclusions relating to the antarctic climate and to the atmospheric circulation of that region, based on actual data and not on hypothesis. In addition to published monographs [14, 11, 2, 5 and others], aerometeorological observation materials of five expeditions have also been published. Existanse of the latter furnishes the opportunity for a large circle of scientists to utilize unique data in connection with their studies of the Sixth Continent. One important adjunct of the above papers (published by the Central Institute of Forecasts) is the "Atlas of Aeroclimatic Charts and Charts of Routes and Recurrence of Cyclones and of Anticylones in the Southern Hemisphere", presenting Antarctica in sufficient detail [9]. The "Aeroclimatic Handbook of Antarctica" is also being prepared for publication by the Antarctic and Arctic Scientific- Research Institute (AANII) in collaboration with the Institute of Aeroclimatology. This publication will provide detailed information on the thermal and wind regimes of the free atmosphere, the distribution of pressure and humidity at various levels over the region.

In this article we will confine ourselves to a discussion of some of the results of the investigations. The actinometric observations brought out the peculiarities of the radiational balance, both at the surface of the earth and in the

lower and middle troposphere. The annual radiational balance of the underlying surface has a negative index. In the central regions of Antarctica a small positive balance is observed only during the two summer months, when the elevation of the sun is over 17°. Over glacial and snowy surfaces it amounts to approximately 2 K calories/cm^2 per month. From April to October the monthly values of the radiational balance along the coast are approximately -2.0, -2.5 K cal/cm^2 and these increase farther inland to -1.0, -1.5 K cal/ cm^2 per month, due to the increased strength of surficial inversions. Loss of heat in the underlying surfaces of the Antarctic Continent attributable to radiation is compensated through the prevalence of unusually high rate of turbulent exchange.

As a result of exceptionally high transparency, purity and dryness of antarctic air, the intensity of direct solar radiation at equal solar elavations above the central areas of the continent is 20% higher than that of moderate latitudes. The maximum intensity of direct radiation is over 1.7 cal/cm^2 per month. In contrast to the Arctic, here the direct radiation provides a basic input into the total radiation (60 - 80%). Due to a substantial variation in clodiness, the inflow of solar heat in the form of scattered radiation is much lower in Antarctica than in the Arctic, where it amounts to nearly 74%.

A large secondary reflection of radiation results from cloudy conditions, as well as from the high reflection factor, whose mean annual magnitude above the snow cover is over 85%. With the existance of the latter and the presence of stratus clouds, the avalanche of scattered radiation is 1.5 times greater than that existing over surfaces having a lower reflection factor. In summer the highest values of summary radiation are observed in the area of the pole of relative inaccessibility. In the central regions of the Continent the summary radiation in December reaches the highest total on earth (32 K cal/cm^2 per month). The effective radiation in Antarctica for ice and snow surfaces averages 20 - 25 K cal?cm^2 per year. The greatest contribution to the study of radiational balance of Antarctica was the work of N.P.Rusin [11].

Of equal interest are the direct measurements of components of the balance of short wave radiation at different elevations in the troposphere, performed in Antarctica by V.I. Shlyakhov [17] aboard an airborne meteorological observatory. He found that the density of the streams of direct and scattered solar radiation varies very gradually with altitudes, with small vertical gradients. For direct radiation up to an altitude of 4 KM they remain nearly constant (-0.004 cal/cm^2 per month per 100 M). The summary radiation continues to increase uniformly with the altitude, while the reflected one and the scattered radiation decrease rapidly.

Topographic features and the nature of circulation produce a thermal regime of the antarctic air, near the ground and at various altitudes, quite different from that of the high latitudes of the northern hemisphere. Distribution of air temperatures at various antarctic latitudes near the underlying surface is shown in detail on charts drawn by E.S. Rubinshteyn and R.F.Sokhrina [12] . The coolig process of the air takes place here gradually throughout the winter due to the prevailing radiational balance.

The lowest temperatures in Central Antarctica occur at the end of the polar night (in August). At that time, in 1960, an air temperature of -88.3° was recorded at the Vostok station, while at the same time in the Arctic the temperature does not drop below -50°. From Central Antarctica to the coast the temperature rises gradually, depending upon the latitude of the location, due to the increasing influence of the sea and other factors. There are theories that the decline of air temperatures in areas located on gentle slopes begins with cascading of cold air from the elevated central plateau, the process subsequently accelerated through radiational cooling.

The annual amplitudes in Antarctica increase from $20-25^{\circ}$ on the coast to $50-60^{\circ}$ in the central regions. The uniformity of the annual temperature progression is interrupted due to the existance of two winter temperature minimums. The

rise of temperature in midwinter in the various continental regions is attributable to advection of warm air from the northerly regions which frequently embraces the entire troposphere. A prolonged period of such advection in some years produces "warm core" winters. The established trend toward a reverse diurnal temperature progression during the polar Arctic night is also typical of Antarctica, as shown by E,S.Rubinshteyn. A rise in air temperatures during the polar night hours is a fairly common occurence, so far unexplained.

Based on our analysis of the few, but sufficiently precise, elevations of a meteorograph by a kite, accomplished during Berd's antarctic expedition in 1929 and 1934 [7], we established that the most typical feature of the temperature change with altitudes is the existance of strong surficial temperature inversions, even during the warm season of the year. This gave us reasons to assume that such inversions must be more frequent in winter and that they would be more pronounced and would have greater development in the vertical direction. Papers [14, 5, 2 and others] fully confirm this.

From a subsequent paper of A.M.Kovrova [10], based on a great number of current observations, it follows that surficial inversions at intracontinental stations occur throughout the year, as a result of radiational cooling of the underlying surfaces.

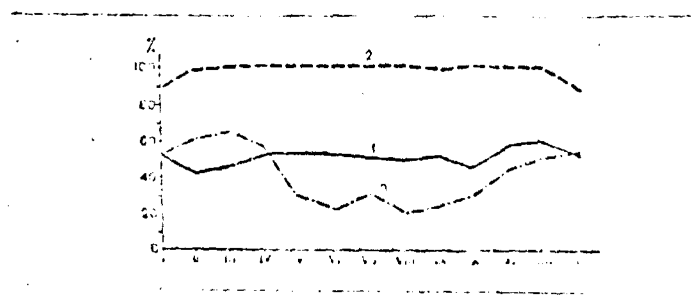

Fig.1. Repetition of inversion at stations.
1 - Mirnyy; 2 - Vostok; 3 - Dixson Island

Figures 1 and 2 show the recurrence and intensity of inversions at two Antarctic points and one point in the Arctic. In winter the average magnitude of inversions in Central Antarctica exceeds 1 KM; when the radiational inversions combine with sinking or frontal ones their face can increase up to 3 KM or more, in summer - up to 1 to 1.5 KM.

In the Oasis station area in summer, when the base formations are free of ice and snow and are strongly heated, surficial temperature inversions are non-existant. On the portion of the antarctic coast where the phenomenon of effluent winds is clearly defined, inversions are often associated with effluence of cold air. Effluent winds frequently intensify the existing local inversions which then continue even in the presence of high wind velocities. This frequent presence of temperature inversions in the lower kilometric stratum even affects the rate of change of mean temperatures at various altitudes. A normal decline of temperature occurs in the troposphere, above the inversion stratum.

The mean annual temperature of the troposphere above Antarctica is nearly 5 - 10° lower than that of the Arctic, chiefly due to the effect of the winter months. The summer temperature in the stratosphere over Antarctica and the Arctic is nearly the same, but in winter it is lower in the Antarctic. In summer the temperature in the Antarctic increases very slowly with the altitude and becomes equal to the temperature at the earth's surface at an altitude of 20 - 22 KM. In winter the temperature drops gradually. From records covering many years, the August temperature of the 18 - 20 KM stratum over Mirnyy is approximately -80°, over the Vostok station -85°, over the South Pole it approaches -90°. Thus, the winter temperature of the stratosphere becomes lower with an increase in latitude.

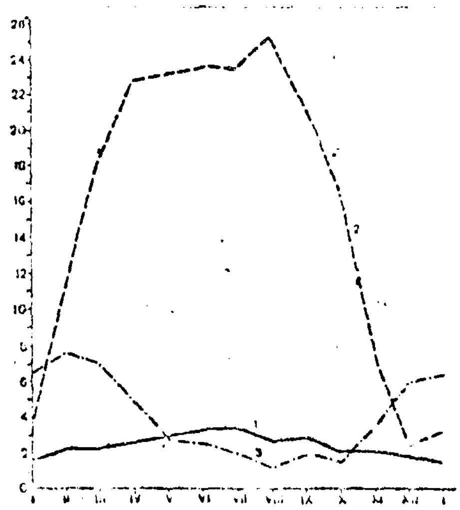

Fig.2. Intensity of inversion at stations.
1 - Mirnyy; 2 - Vostok; 3 - Dickson Island.

It is interesting to compare temperatures over the two poles observed during the IGY period. In summer in the surficial stratum above the South Pole the air temperature is 20 - 25° lower than over the North Pole, in winter it is 25 - 30° lower. At the tropopause level the winter temperature over the South Pole is 15 - 18° lower than over the North Pole. Great differences in winter temperatures were also discovered in the stratosphere. At an altitude of 20 KM above the South Pole the temperature is 20 - 25° lower. A reverse relation exists in summer when the difference in temperatures is only 5°.

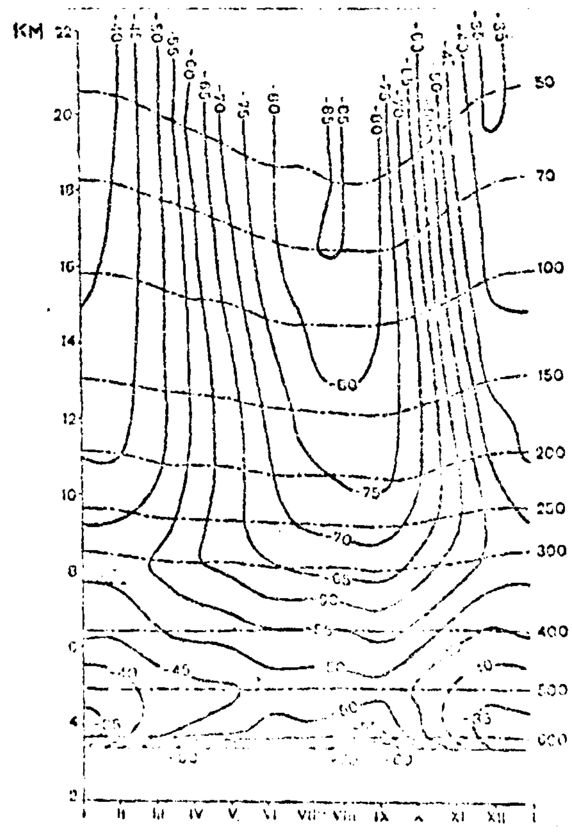

Fig. 3. Annual variation of temperatures above Vostok station
1 - isotherms 2 - isobars (in millibars)

The annual amplitudes are of considerable interest. Up to an altitude of 3 KM the amplitude decreases from 18 - 20° to 11°, above that elevation it increases and at an altitude of 16 KM becomes 36 - 40°. Over the Arctic the annual amplitude in the troposphere is much greater, becoming equal at the tropopause level. A reverse relationship prevails in the stratosphere.

As an example we present the thermoisopleths of the annual curve of temperatures at the Vostok station, plotted for standard altitudes (Fig.3), derived from data of radio-probe observations, through the end of 1960. As stated in the report of the Sixth Continental Expedition, the annual curve of temperatures in the stratosphere is in close agreement with the annual curve of the total ozone content, which has lately been systematically determined in Antarctica.

An analysis of temperatures at various altitudes has led to a determination of their substantial deviations from the average ones over a period of several years. This applies to both the annual averages and to seasonal values and the deviations are especially high during the winter months. In the troposphere these deviations for individual seasons amount to 3 - 5°, in the stratosphere they are sometimes over 10°. It should also be noted that the deviations on both the positive and the negative side often continue in a given year over a period of several months. These deviations are

attributable to the changes in atmospheric circulation from one year to another.

In all regions of Antarctica we noted substantial non-periodic temperature fluctuations which are definitely characteristic of its day-to-day variability. This question has not yet been thoroughly studied. However, some preliminary characteristics give us reason to believe that interdiurnal variation in Antarctica is not very different from that of the Arctic. This, in turn, speaks of the strong activity of synoptic processes in Antarctica.

The altitude of the tropopause (see Fig. 3) depends directly upon the air temperature in the troposphere and the stratosphere: with a drop in temperature the altitude of the tropopause increases and vice versa. Thus, in contrast to the moderate and high latitudes of the northern hemisphere, the maximum altitude of the tropopause in Antarctica is observed in winter. This phenomenon can be attributed to a number of causes, however, in our opinion these explanations are based on insufficient data and could be rendered more precise after some additional investigations.

The annual course of the altitude and temperature of the tropopause in both polar regions is shown in Fig. 4. From year to year there may be some substantial changes in both the altitude of the tropopause and of the temperature at that level. The greatest magnitudes are reached in winter. Non-periodic changes of altitude and temperature of the lower

border of the tropopause depend chiefly on changes of pressure field systems. Their greatest magnitudes are attained within mobile occluded cyclones, in which the frontal zones have an extensive vertical development. In such cases the change in the altitude of the tropopause may reach 5 KM in a period of 24 hours.

We consider the distribution of altitudes and temperatures of the tropopause in various aerial masses, determined for Antarctica by E.I.Tolstikov, to be a matter of greatest interest. From an analysis of synoptic charts and records of thermal probing of the atmosphere he established the existence of four types of aerial masses along the coast and in Central Antarctica:

1) continental antarctic air (KAV);
2) marine antarctic air (MAV);
3) moderate latitude air (VUSh);
4) tropical air (TV);

The figures for the altitude and temperature of the tropopause for each of these aerial masses for January and July are presented in Table I. The complex relief of Antarctica has a strong influence on the meteorological regime of a number of regions of that continent, especially in the coastal zone. This influence has the strongest effect on the velocity and direction of wind in the bottom kilometric stratum. As a result of the effect of local factors the wind direction in

that stratum is distinguished by its high stability, since this is where the effluent winds originate, because of the strong cooling of air on the slopes of the glacial plateau and its movement down the slope due to gravity. At high altitudes the wind velocity attains normal magnitudes, dependent mainly on the circulating conditions.

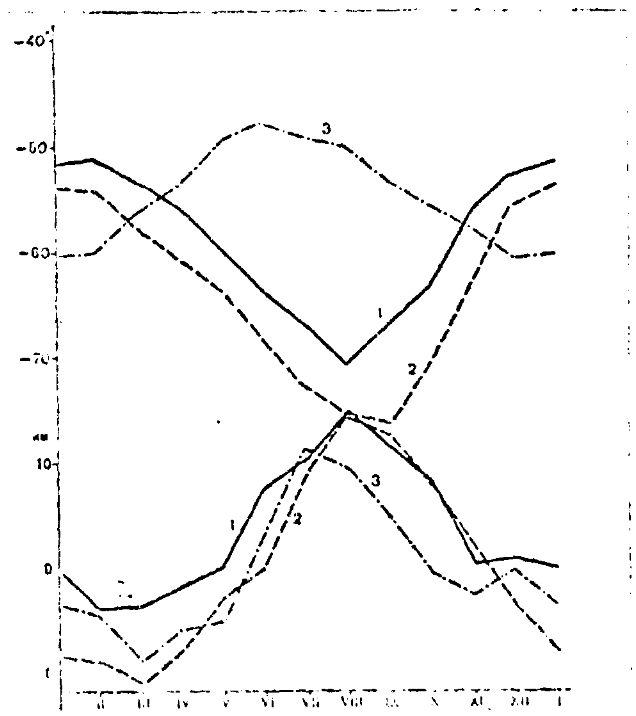

Fig. 4. Yearly course of altitude and of temperature of the tropopause at various stations.

1 - Mirnyy; 2 - Vostok; 3 - Dickson.

Alteration of wind by local factors was already noted by the Baird expedition in the course of their sounding balloon observations in 1928 and 1929. The report of this expedition states that it was only possible to predict correctly proximate changes of the weather on the basis of movement of the

upper air strata [4] . This question was properly exposed by Soviet scientists N.P.Rusin, S.S.Gaygerov, L.V.Dolganov and (in most detail) by G.M.Tauber. They established that effluent winds exist throughout the year. During some months their recurrence reaches 90%.

Table 1

Altitude of the lower edge of the tropopause for various aerial masses (in Kilometers)

Regions	KAV		MAV	
	I	VII	I	VII
Central	7.6 - 9.0	7.9 - 9.0	8.0 - 9.2	8.3 - 10.5
Coastal	7.2 -8.7	8.0 - 8.6	8.0 - 9.5	7.5 - 10.5

Regions	VUSh		TV	
	I	VII	I	VII
Central	-	8.5-10.5	-	10.3-10.0
Coastal	8.1-10.5	9.5-11.0	10.5-11.0	10.5-11.6

The wind force is influenced by the slope's surface shape. Effluent winds are most highly developed in three coastal areas, where long slopes rise steeply. For instance, in the Mirnyy region, where the topography for 50 KM inshore has an inclination of 10°, the wind velocity of persistent south-easterly and easterly currents reaches hurricane force. Here its annual amplitude near the surface of the earth is 2-3 times greater than that of the interior regions of Antarctica. At

Mirnyy 40 - 60% of all storms are associated with effluent winds, whose intensity depends also on the synoptic conditions. Those winds vary according to season, becoming stronger in winter when the radiational cooling is strongest. In addition to their effect on the temperature gradient in the bottom air stratum, they strongly affect the moisture distribution of the atmosphere.

From the above it becomes evident how important it is to know the distribution of wind in the lower stratum of air. Consequently, much attention had to be devoted to the study of effluent winds in the course of subsequent expeditions. Many papers deal with the distribution of wind in free air. We have obtained summary data relative to wind, covering a long period of time. For example, we have data on Mirnyy covering a period of six years. These statistics tell us that winds of the eastern component predominate in summer, in the 850-600 Millibar (65%), then the western components' recurrence begins to increase gradually, reaching 73% at the 200 Millibar level.

Noticeable strengthening of anticyclonic circulation in the stratosphere begins at 50 Millibars. Here the recurrence of winds of the eastern component is 57% and it increases to 91% at the 30 Millibar level. Winter conditions in the 850--600 Millibar stratum are characterized by a similar wind direction, but at greater velocities. Western winds begin to

predominate gradually, beginning with the surface of 600 Millibar. At the 70 Millibar level their recurrence is over 95%. In the Vostok station area the characteristic distribution of winds is as follows. In summer winds of the southern quadrant predominate from 600 to 300 Millibar and of the western quadrant, up to 100 Millibar. Recurrence of the eastern quadrant increases noticeably only from the 100 Millibar surface (approximately 45%). Reliable winter data is available only up to the 100 Millibar surface. Southwestern and western winds are predominant, considering the entire stratum. On the basis of isolated observations, recurrence of winds from these directions becomes even greater at higher altitudes. We have every reason to believe that in Antarctica the vortex stability is greater than in the Arctic.

Observations over various regions of Antarctica show that the elimination of the polar vortex, due to the intensive warming caused by the appearance of the sun, occurs first at great altitudes in the stratosphere and then spreads gradually downward into the tropopause. Figures 5 and 6 present the characteristics of wind velocity, based on readings taken over a period of many years over the Mirnyy and Vostok stations. Similarity exists only in summer and is especially evident in the stratosphere. In the troposphere the wind velocity is somewhat lower over the Arctic, as the

pressure gradients over Mirnyy are greater. In winter, above Mirnyy, the wind velocity at all altitudes in the troposphere and stratosphere is much greater than the wind velocities over the Vostok station.

At the 50 Millibar level over Mirnyy the wind velocity is 2.5 times greater than at the surface of the earth, where as a result of stronger effluent winter winds their average velocity is nearly 14 M/sec. For this reason the annual amplitude of wind velocity over Mirnyy is very large. For example, at the 100 Millibar level it is twice as great as at the Vostok station. Lower wind velocities at the Vostok station are due to the fact that in winter it is either in the anticyclone zone, or near the center of a depression, while the Mirnyy area is in the zone of large gradients at all levels. The Amundsen-Scott station is subject to synoptic conditions almost identical with those prevailing at the Vostok station.

High wind velocities in the upper troposphere and lower stratosphere of the coastal regions of Antarctica are caused chiefly by jet currents, observed here at any time, with durations of 1 - 7 days. Most often they exist in the troposphere during meridianal circulation and in approximately 90% of the cases the axis of the jet stream is located slightly below the tropopause. As stated by S.S.Gaygerov, at the Mirnyy Observatory in 1957 there were 81 days having

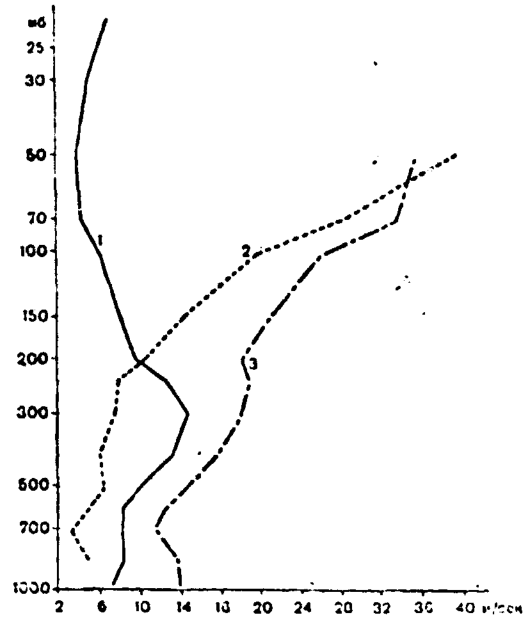

Fig. 5. Distribution of wind velocity at various altitudes over Mirnyy, 1956-1960.
1 - January; 2 - July; 3 - annual amplitude.

jet streams with a calculated minimal wind velocity of 25 M/sec. In 1962, from February to December, they were recorded on 117 days. Of undoubted interest is the information obtained by G.G.Sergeeva relative to recurrence of high-velocity winds (v ≥ 25 M/sec.), related to jet streams (Fig. 7). In June and July at elevations of 300 and 200 Millibar surfaces they represent 30 - 35% of all other wind velocities, at the 70 Millibar level - nearly 85%.

At present we are able to compare the average wind velocities over the South Pole and the North Pole regions (85° N.Lat.) from the results of probing performed during the

ICY period (Table 2). As seen from this table, the summer and winter wind velocities over the North Pole at all altitudes are greater than those over the South Pole. In summer, in the lower stratosphere above the North Pole it decreases more slowly with the altitude than in the case of the South Pole. This is attributed to the differences in the vertical location of the tropopause and the horizontal distribution of pressures. In winter the difference between wind velocities in the lower stratosphere of the two poles is even greater. The differences, as in summer, become understandable when we compare the aeroclimatic charts of the North and the South hemispheres.

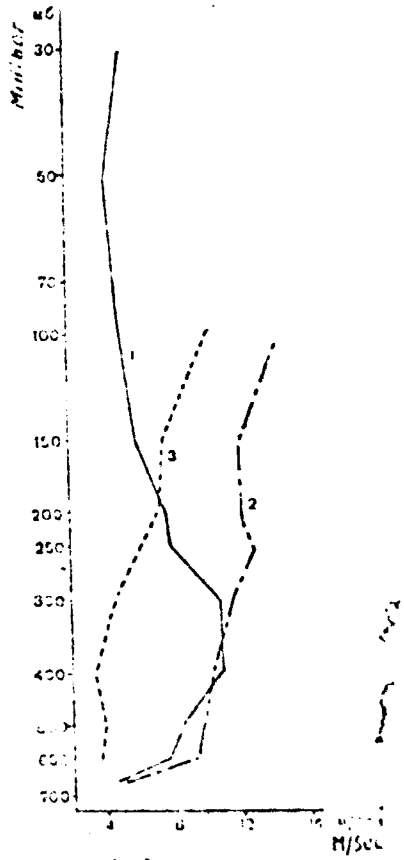

Fig.6. Distribution of wind velocity over Vostok station during 1958- 1960
1 - January; 2 - August; 3 - annual amplitude.

Due to its low air temperatures the Antarctic is outstanding in its very small absolute quantities of moisture and its high relative humidity. The greatest changes in humidity are aperiodic. Especially large fluctuations are produced by changes in wind direction. This is most evident

on the shores of polar seas. The change in humidity is affected by the effluent winds, which produce dynamic warming of the air. The relative humidity undergoes its greatest changes during the collapse of inversion with the rise of very strong winds. On the Antarctic Continent water vapor tension varies from 2.0 - 2.5 on the coast up to 0.01-0.02 in the interior. In the inversion stratum water vapor tension increases with altitude and the stream of water vapor is directed downward.

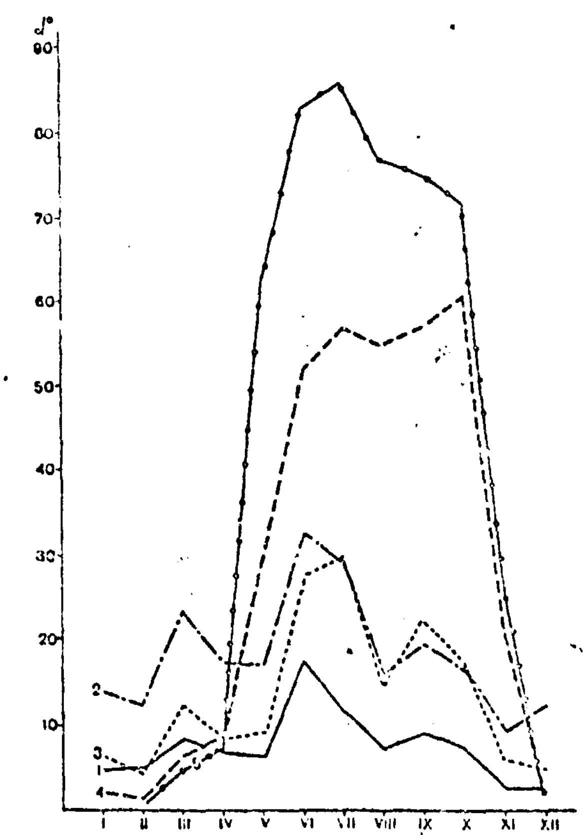

Fig. 7. Annual progress of recurrence of wind with a $v \geqslant 25$ M/sec. over Mirnyy at altitudes of: 500 (1), 300 (2), 200 (3), 100 (4), 70 Millibars (5).

Thanks to the large volume of material accumulated by Soviet meteorologists during the ten years spent in the antarctic and the creation of a synoptic file, it is now possible to make a number of important deductions relative to synoptic conditions and atmospheric circulation, to clarify the courses of cyclones and anticyclones, their recurrence in various regions of the Continent in the course of a year, and to obtain the important characteristics of the aerological structure of pressure-field systems. We have also determined the weather conditions in a number of regions with relations to the synoptic conditions, etc. The greatest contribution toward the solution of these questions were made chiefly by members of the Antarctic Expeditions, in addition to previously mentioned authors [2, 5, 14, 15], O.G.Krichak, V.A.Bugaev, B.L.Dzerdzeevskiy, S.P.Khromov, Kh.P.Pogosyan and others.

It was found that cyclones not only move along the coast of Antarctica, but penetrate the interior of the continent from various directions throughout the year. As to Eastern Antarctica, south of 75° S. Lat. - in the area of the Pole of Relative Inaccessibility, Vostok and Komsomol'skaya stations - the greatest recurrence is that of anticyclones. Cyclones seldom penetrate into this region. Those that reach the central parts of the continent are for the most part active, with a high thermal asymmetry. For example, due to

Table 2.

Average wind velocity over the South (Amundsen - Scott) and North poles (85° N.Lat.)

Altitude (KM)	Velocity (M/sec.)	
	South Pole	North Pole
	Summer	
5.0	9.0	13.0
6.0	10.8	16.0
8.5	12.5	18.5
11.2	7.2	13.5
16.0	4.8	7.2
	Winter	
4.9	11.5	12.7
6.3	13.2	14.0
8.1	13.4	15.0
10.5	10.7	12.5
14.5	7.4	13.2

the existance of a widespread and deep cyclone in September 1965, the advancing warm air masses in its front produced a rise in air temperature of almost 30° at the Vostok station. The interior of the Continent is often penetrated by cyclones in the presence of a stable meridianal form of atmospheric circulation in the moderate latitudes of the southern hemisphere. This, in turn, points partly to the close relationship of antarctic synoptic processes to the macroprocesses of the moderate latitudes.

Concurrent observations of atmospheric circulation in the northern and southern hemispheres led to the discovery of the existance of a close relation between the synoptic processes of the two hemispheres. A qualitative scheme of the possibility of such a relationship was already suggested by A.A.Girs

in 1958. Later, E.P.Borisenkov [3] and A.P.Astapenko, V.S. Sovonichev [1] obtained the quantitative characteristics of atmospheric circulation, which enabled them to evaluate the close relationship of atmospheric circulation of the northern and southern hemispheres. All this points to the fact that the atmosphere is a unit, therefore, as pointed out by A.A.Girs [6], the methods of long-range weather prediction must be based on the mechanisms of general atmospheric circulation of the entire planet. This is why the interest in the study of the southern hemisphere, especially of Antarctica, has grown so rapidly, as reflected by world-wide publications.

The study of the over-all atmospheric circulation requires, first of all, an intensive investigation of the southern hemisphere, specifically of Antarctica, chiefly from the qualitative standpoint. First priority must be given to gathering of information relative to radiation in the free atmosphere and to the vertical distribution of ozone at various altitudes, to the development of an investigation of heat exchange between the underlying surface and the adjacent atmospheric stratum. An adequate study of the atmosphere without knowledge of the above factors is unthinkable. Rocket investigations of the upper stratosphere and mesosphere would be of great interest.

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